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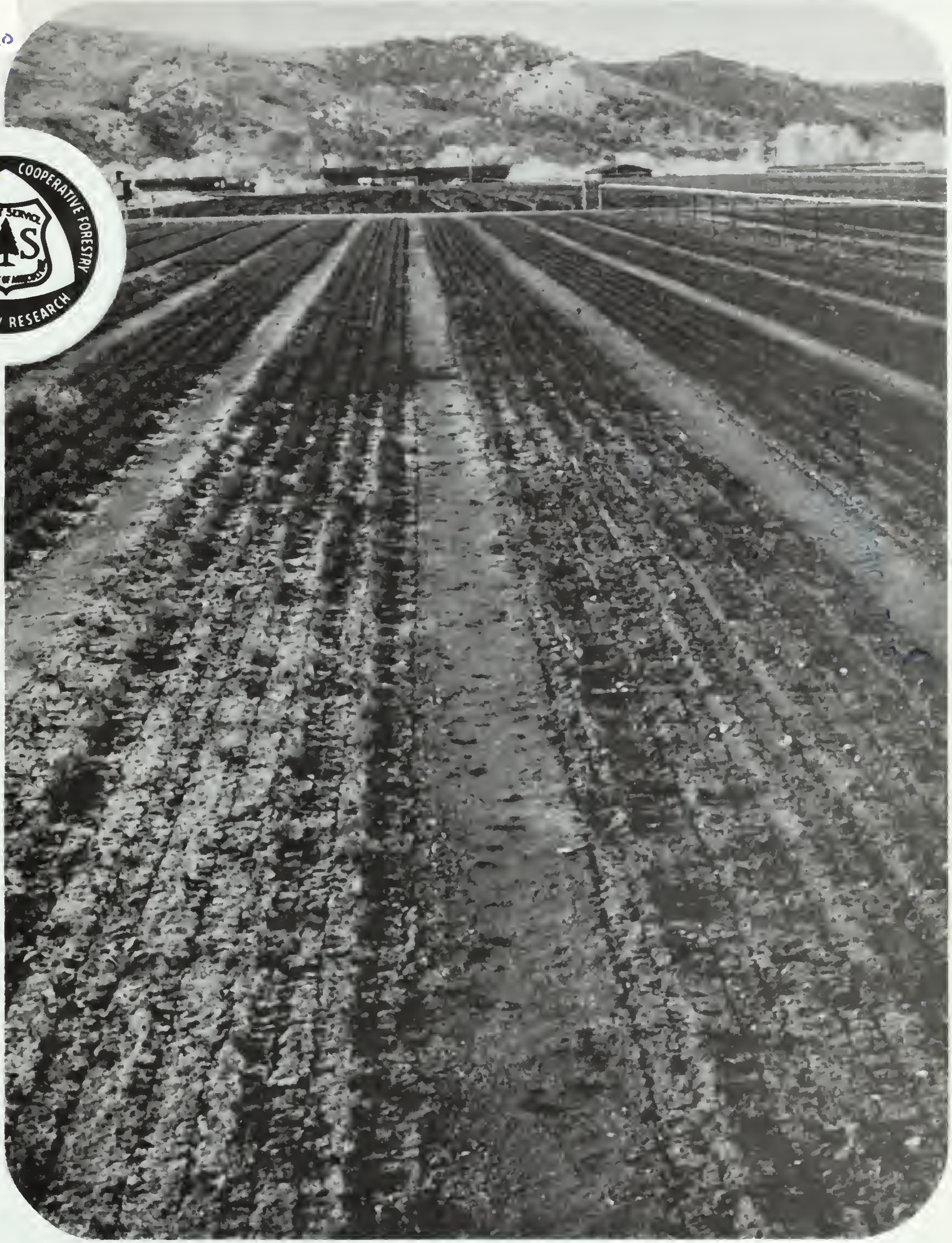

Soil and Water Quality in Relation to Lodgepole Pine Culture

at

Mt. Sopris Nursery

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SOIL AND WATER QUALITY IN RELATION TO LODGEPOLE PINE CULTURE AT MT. SOPRIS NURSERY

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INTRODUCTION

During the spring of 1975 a meeting was held at the U.S.F.S. Mt. Sopris Tree Nursery at Carbondale, Colorado to discuss chronic nursery problems. One of the more persistent problems has been the poor survival and growth of lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) in certain blocks of the nursery.

In general, nursery soil at Mt. Sopris has a higher pH than is optimum for coniferous stock production. Based on a 1968 survey soil pH values varied from 5.0 - 7.7 over the nursery compared to an optimum level of 5.0 - 6.0 for coniferous seedling culture.[1/] Observations of white chemical deposits on the soil surface at certain locations also indicate saline conditions. In a Canadian study seedling size was directly related to soil pH with the largest seedlings occurring at the lower pH levels (1).

Preliminary water quality tests revealed pH levels approaching 9.0 higher than optimum for irrigation water quality. Ideally, irrigation water should be around neutrality, pH 7.0, which would allow use of ample quantities of water without a buildup of harmful salts. Addition of saline water to soils with already high pH values will necessarily accelerate the soil salinity problem.

The purpose of this investigation, therefore, was to investigate the causes of poor quality lodgepole pine seedling production, specifically in terms of soil and water quality at Mt. Sopris Nursery.

METHODS AND PROCEDURES

Suitability of nursery soil and irrigation water was studied by means of a series of soil and water samples collected at the nursery and analyzed for chemical composition.

1/ Wilde, S. A., Mt. Sopris Nursery Handbook

Irrigation water samples were collected bimonthly during the 1975 growing season. Samples were taken from the Roaring Fork River to monitor water quality in the irrigation ditch system and also from the three irrigation wells which are primarily used early in the season before river water is available. The sampling procedure consisted of collecting water in clean plastic bottles, labeling and storing for analysis. Water from the three irrigation wells was mixed to provide an average sample for the total well system. Streamflow records for the Roaring Fork river were obtained from the U. S. Geological Survey guaging station at Glenwood Springs, Colorado.

Soil samples were collected from nursery blocks with contrasting histories of lodgepole pine culture. Two blocks that produce good crops of lodgepole pine were sampled as were two blocks with chronically poor pine production. Five soil samples from within the furrow slice were collected and placed in a plastic bucket and mixed thoroughly to give an average sample for each nursery block. An approximate one-pint sample of this soil mixture was placed in a paper soil bag, labeled and stored for analysis. Duplicate soil samples from one nursery location, Block 5, were submitted as separate samples to test the precision of the laboratory analysis and provide a quality check.

All soil and water samples were refrigerated during transport to minimize chemical changes that might occur as a result of overheating. These samples were taken to a private analytical laboratory for chemical analysis. Agricultural Consultants Laboratory of Brighton, Colorado was selected because of their experience in agricultural soil and water quality.

RESULTS AND DISCUSSION

Irrigation Water Quality - Analysis of water samples taken four times during the 1975 growing season indicated that pH values were not as high as the preliminary tests had indicated. Irrigation water pH values ranged from 7.7 to 8.0 during the season (Table 1). These values, although slightly alkaline, fall well within the range of pH values reported for Ontario nurseries, 6.9 - 8.3.

Although pH can be useful in determining water quality, a more relevant measure of water quality is electrical conductivity (E.C.), a measure of the total amount of dissolved salts in solution. Electrical conductivity values for irrigation water sources at Mt. Sopris ranged from 360 - 500 mcmhos per cm. (Table 1). In general, irrigation waters with conductivity values below 750 mcmhos/cm are satisfactory although salt sensitive species may be adversely

Table 1 - Irrigation water quality at Mt. Sopris Nursery during 1975 growing season

General Indexes	Units	March Well	March River	May Well	May River	July Well	July River	Sept. Well	Sept. River	Comparative Values	Reference
pH	Logarithmic Units	7.7	7.7	7.6	7.8	7.8	7.9	7.8	8.0	6.9 - 8.3	(Armson and Sadreika, 1974)
Electrical Conductivity (E. C.)	mcmhos/cm	500	475	490	400	440	360	500	450	250 - 750 = Medium Salinity Hazard	(U.S. Salinity Lab., 1969)
Sodium Adsorption Ratio (S.A.R.)	None	0.02	0.40	0.50	0.55	0.50	0.50	0.30	0.30	0 - 10 = Low Sodium Hazard	(U.S. Salinity Lab., 1969)
Specific Ions											
Sodium	mg/1	0.7	15	18	17	16	15	12	9	1 - 13	(Armson and Sadreika, 1974)
Calcium	mg/1	86	78	73	58	67	51	73	67	4 - 55	(Armson and Sadreika, 1974)
Magnesium	mg/1	20	19	14	8	12	8	15	12	2 - 22	(Armson and Sadreika, 1974)
Boron	mg/1	0.10	0.05	0.05	0.05	0.10	0.05	0.05	0.05	0.3 - 1.25 = Satisfactory for Sensitive Crops	(U.S. Salinity Lab., 1969)
Sulfate	mg/1	90	150	62	76	60	38	60	79	5 - 130	(Armson and Sadreika, 1974)

Analyses performed by Agricultural Consultants Laboratory

affected by water with values of 250 - 750 mcmhos/cm (3). Irrigation water from both wells and river is classified as medium salinity water which can be used if a moderate amount of leaching occurs.

The third index of water quality is the sodium adsorption ratio (SAR); this value reflects the effects of exchangeable sodium on soil properties. The SAR for Mt. Sopris irrigation sources varied from 0.02 to 0.55 (Table 1), which would be classified as low sodium hazard water. Low sodium water can be used on almost all soils with little danger of harmful sodium levels developing (3).

Specific salt ions may cause more of a problem in irrigation water than the level of total salts. Concentrations of individual salts in water sources at Mt. Sopris compare favorably with those reported for forest nurseries in Ontario (Table 1). Calcium concentrations are notably higher at Mt. Sopris but these levels reflect the chemical nature of local geological formations which contain limestone and gypsum.

Water quality of the Roaring Fork River fluctuated with streamflow during the 1975 sampling period (Figure 1). Water pH was unrelated to streamflow but gradually increased through the growing season; this was probably a reflection of increased biological activity within the river. Total dissolved salts, as measured by the electrical conductivity, varied inversely with streamflow. During the early part of the season increased snowmelt diluted the salt concentration in the river whereas lower streamflows later in the season contained more dissolved salts on a relative scale. The sodium adsorption ratio (SAR) varied directly with streamflow during the season. These increased sodium levels are the result of the snow melt on the highly erodible Eagle Valley Evaporite formation which contains large quantities of sodium salts.

A relative comparison of chemical quality of well water and river water during the 1975 season demonstrates that the river provides better quality water than do the wells (Figure 2). The sodium adsorption ratio and pH do not vary significantly between the two sources. Total dissolved salts (E.C.), which is the best single indicator of water quality, are consistently higher in the water from the irrigation wells. The principal irrigation period at Mt. Sopris is the early spring before river water becomes available. Whenever possible, water should be taken from the river to minimize the possibility of salt buildup in nursery soils.

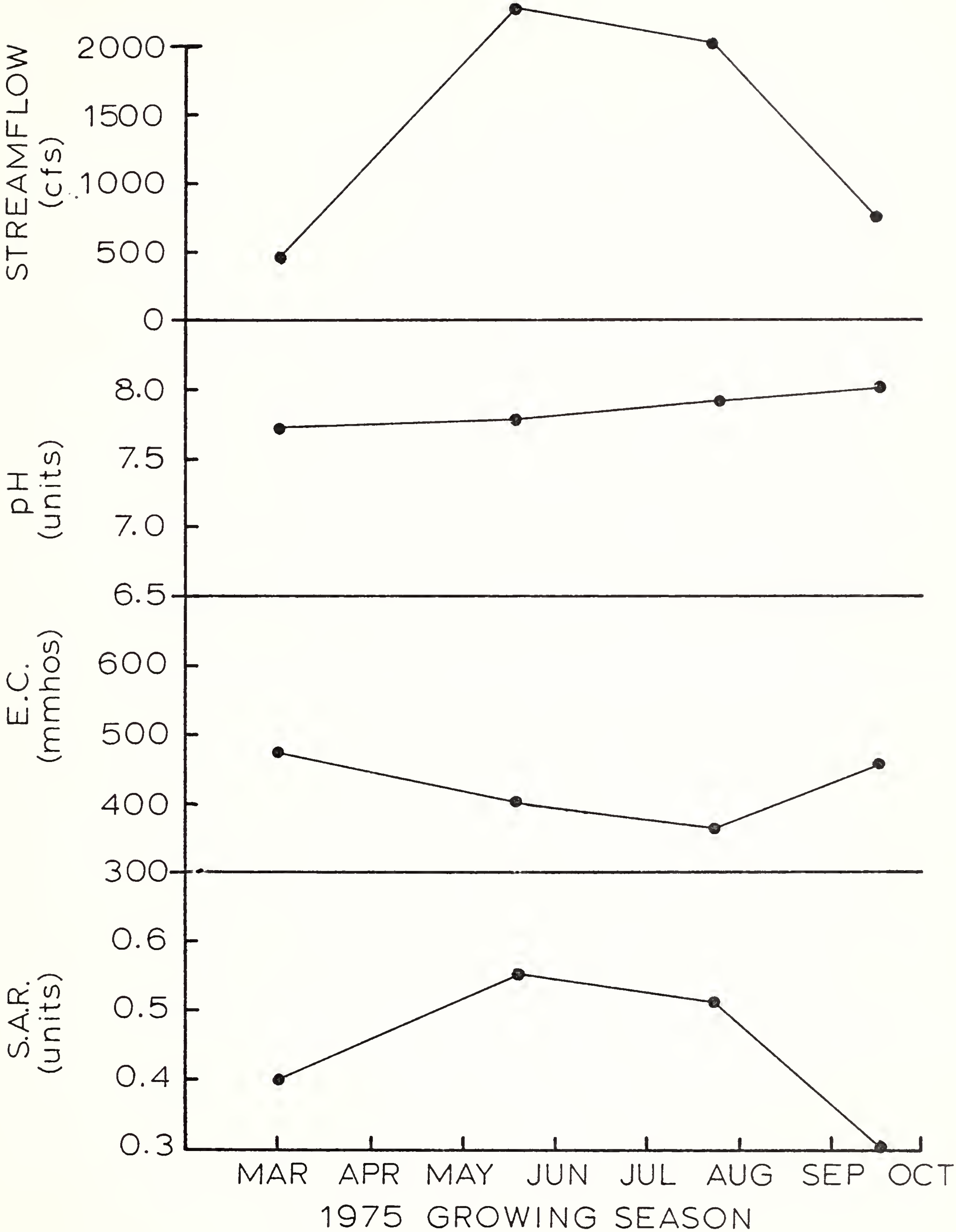

Figure 1 - Relationship of water quality to streamflow of Roaring Fork River.

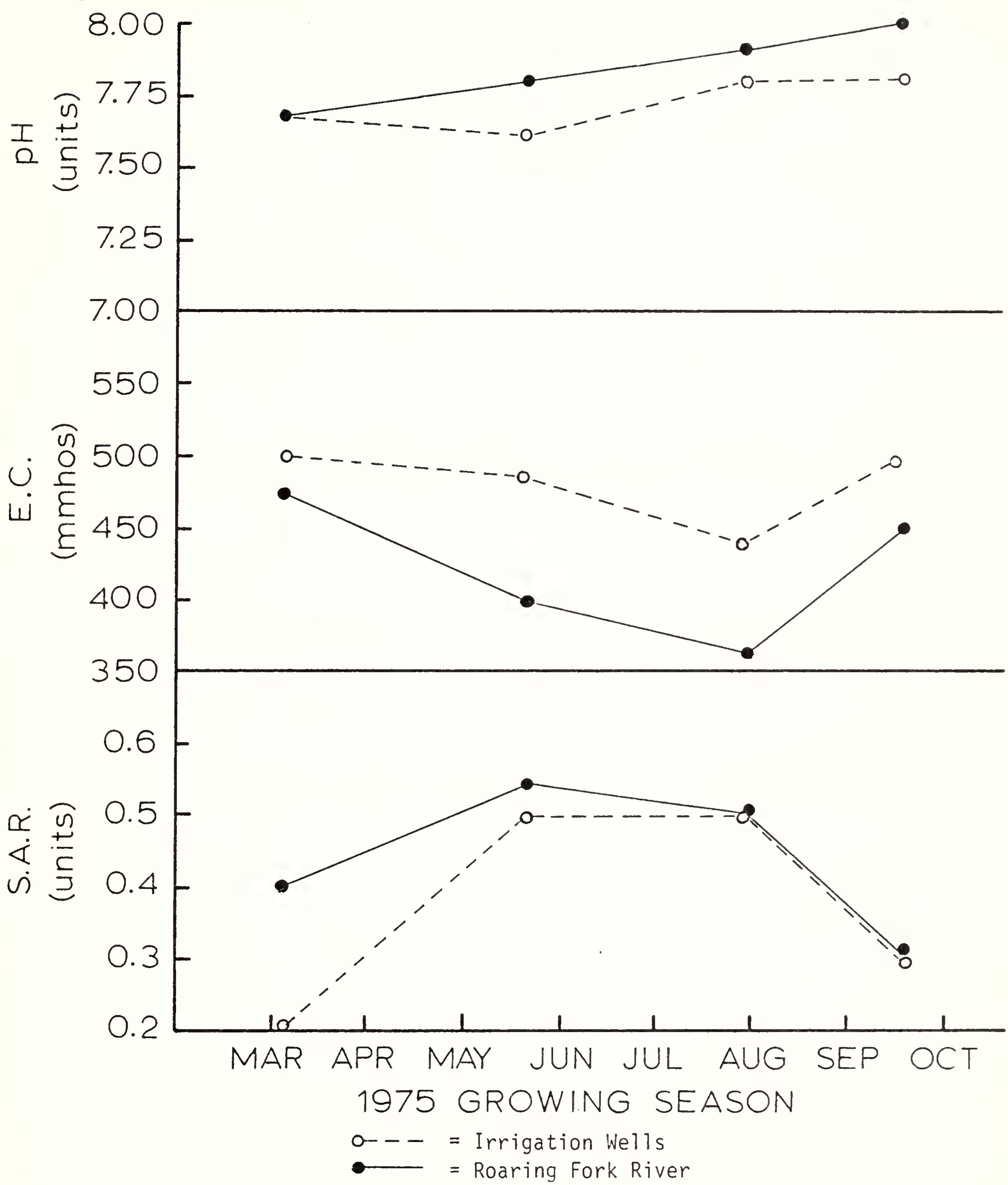

Figure 2 - Comparison of water quality of irrigation wells with the Roaring Fork River.

Soil Quality - Chemical tests of the duplicate soil samples from Block 5 confirm the precision of the chemical analyses (Table 2). The comparability of the two samples is remarkable, considering that these samples were taken from a mixture of 5 soil samples. The largest divergence between the two analyses are the nitrogen forms, NO_3 and NO_2. Differences are to be expected in soil nitrogen levels because soil microorganisms are constantly converting nitrogen from one form to another and the stability of the various forms depends on soil conditions. The close agreement of this test adds credence to the analytical results of the other tests.

Comparative analyses of the good and poor production lodgepole pine soils revealed few differences (Table 3). Most soil factors did not vary between the good and poor samples including texture, cation exchange capacity (C.E.C.), pH and organic matter (O.M.). Most plant nutrient levels are comparable between the two soil samples, also.

One obvious difference, however, is that two forms of soil nitrogen are almost twice as high in the poor growth samples (Table 3). Both of these nitrogen forms are transitory as they are rapidly broken down by microorganisms or are leached from the soil profile. Their presence in higher concentrations in the poor growth plots indicates that some factor is inhibiting these processes.

Effects on Lodgepole Pine Culture - Dissolved salt levels in irrigation water at Mt. Sopris Nursery are not sufficiently high to cause injury to most plants. Water from both well and river was classified as medium salinity water which can be used on all but salt-sensitive species if a moderate amount of leaching occurs.

Reports on the salt tolerance of lodgepole pine are contradictory. In general, members of the family Pinaceae have not been considered to be salt tolerant (4). In a road salt damage study, however, lodgepole pine exhibited low susceptibility to salt injury compared to other conifers (5). Tree seedlings are more prone to salt damage because their root development is restricted to a limited part of the soil profile. The major proportion of the dissolved salts in the water sources at Mt. Sopris consists of calcium and magnesium salts rather than sodium; calcium and magnesium are not considered to be directly toxic to plants (3). As long as soil structure and irrigation practices permit adequate leaching, water quality should not be a problem at Mt. Sopris Tree Nursery.

Table 2 - Comparison of duplicate soil samples from Mt. Sopris Nursery

Soil Factor	Sample 1	Sample 2
Texture	Silty Loam	Silty Loam
pH (Units)	6.5	6.6
C.E.C. (meq/100g)	15	14
Salt (Mmhos/cm)	0.3	0.3
Na (Meq/100g)	0.5	0.5
Lime (%)	0	0
O.M. %	4.6	4.0
NO_3 (ppm)	25	38
NO_2 (ppm)	1.6	2.1
P (ppm)	22	20
K (ppm)	110	110
Ca (ppm)	1400	1400
Mg (ppm)	210	210
Zn (ppm)	25	25
Fe (ppm)	50	30

Analyses performed by Agricultural Consultants Laboratory

Table 3 - Comparative analysis of lodgepole pine soils at Mt. Sopris Nursery

Soil Factor	Good Production Record Block 2	Block 8	Average	Poor Production Record Block 5	Block 13	Average	Notable Difference
Texture	Silty Loam	Silty Loam	Silty Loam	Silty Loam	Silty Loam	Silty Loam	
pH (Units)	6.8	7.0	6.9	6.5	7.4	7.0	
C.E.C. (meq/100g)	13.0	9.0	11.0	15.0	10.0	12.5	
Salt (mmhos/cm)	0.2	0.2	0.2	0.3	0.2	0.2	
Na (meq/100g)	0.7	0.4	0.6	0.5	0.5	0.5	
Lime (%)	0	0	0	0	0	0	
O.M. (%)	4.0	2.4	3.2	4.6	2.9	3.8	
NO_3 (ppm)	8.0	15.0	11.5	25.0	20.0	22.5	*
NO_2 (ppm)	0.9	1.2	1.0	1.6	1.7	1.6	*
P (ppm)	21	11	16	22	15	18	
K (ppm)	130	110	120	110	170	140	
Ca (ppm)	1400	1100	1250	1400	1200	1300	
Mg (ppm)	170	110	140	210	130	170	
Zn (ppm)	16	3.3	9.6	25	12	18	
Fe (ppm)	50	24	37	50	9	34	

Analyses performed by Agricultural Consultants Laboratory

High levels of soil nitrogen in the poor production blocks may be damaging the lodgepole pine seedlings. Nitrite (NO_2) is extremely toxic to all plants and although nitrate (NO_3) is not directly harmful, excessive concentrations were found to be damaging in an associated study.[1/]

The unusually high concentrations of nitrogen in the poor production blocks indicate that leaching is not occurring. Subsurface soil characteristics may be responsible for this condition although further work is needed to confirm this hypothesis. The overhead sprinkler system currently in use at Mt. Sopris may be partially responsible for this condition. Use of overhead sprinklers over a period of time may lead to "puddling" which will also prohibit proper leaching.

The principal source of soil nitrogen at Mt. Sopris Nursery is fertilizer applications. Nitrogen fertilizers should not be applied merely as a matter of policy; soil and foliage analysis should be used to prescribe fertilizer applications. High nitrogen fertilizers, especially ammonium nitrate, should not be used in these problem areas.

RECOMMENDATIONS

1. Due to its higher water quality, the Roaring Fork River should be used as the primary irrigation source for Mt. Sopris Nursery.

2. Irrigation water should be applied at rates sufficient to insure leaching of soluble salts from the soil profile.

3. Irrigation water quality does not appear to be a problem at this time. To insure future water quality, a program of periodic tests on well and river water is recommended.

4. Fertilizer amendments, notably ammonium nitrate, should not be applied to these poor production blocks unless foliage or soil tests indicate that they are needed.

5. A soil structural analysis should be conducted to investigate the problem of inadequate leaching in the poor production areas.

1/ Landis, T. D., 1976. Nitrogen fertilizer injuries pine seedlings in Rocky Mountain Nursery. Manuscript in Preparation.

LITERATURE CITED

1. Armson, K. A. and V. Sadreika. 1974. Forest tree nursery soil management and related practices. Forest Management Branch, Ontario Ministry of Natural Resources, 177 p.

2. Hem, J. D. 1970. Study and interpretation of the chemical characteristics of natural water. U. S. Geological Survey, Water Supply Paper 1473, 363 p.

3. U. S. Salinity Laboratory. 1969. Diagnosis and improvement of saline and alkali soils. USDA Agri. Handbook No. 60, 160 p.

4. Monk, R. W. and H. B. Peterson. 1962. Tolerance of some shrubs and trees to saline conditions. Proc. Amer. Soc. Hort. Sci. 81:556-561.

5. Scharpf, R. F. and M. Srago. 1974. Conifer damage and death associated with the use of highway deicing salt in the Lake Tahoe Basin of California and Nevada. USDA-Forest Service, California Region, Forest Pest Control, Technical Report 1, 16 p.